SIMULATION AND FORECASTING TOOL IN CRIMINOLOGY

- Doctoral work. UCM - start November 2007
- Goal: help to understand the evolution of crime rates under different economical, demographic, social, legal, etc. factors
- System with two Components:
  1. **Dynamical Model - Sociodynamics (Weidlich)**
  2. **Exploitation: DataWarehousing techniques & Graphical User Interface**
- Prototype during Master Grade in Applied Mathematics. UNED - 2006

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SOCIODYNAMIC (Weidlich):

- Definition of groups in the population under study
  1. **Demographic factors**
  2. **Economic factors**
  3. **Criminality factors**

- Socioconfiguration vector: Vector whose components are the number of individuals in each group

$$\mathbf{n} = (n_N^1, n_C^1; n_N^2, n_C^2)$$

- Estimate the probabilistic ratio of transitions between groups:

$$p_{ji}^{\alpha}(t) = \nu_{ji}(t)\exp\left[u_j^{\alpha}(\mathbf{n}_{ji}(t)) - u_i^{\alpha}(\mathbf{n}(t))\right],$$

$$i, j = N, C \quad \alpha = 1,2$$

- Probability to find the Socioconfiguration at t in **n**: P(**n**;t)

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SOCIODYNAMIC (Weidlich):

- Evolution of Socioconfiguration given by Master Equation of Probability (Stochastic differential equation)

$$\frac{dP(\mathbf{n};t)}{dt} = \sum_{i,j,\alpha} p_{ji}^{\alpha}(t)(n_i^{\alpha}+1)P(\mathbf{n}_{ji}^{\alpha};t) - \sum_{i,j,\alpha} p_{ji}^{\alpha}(t)n_i^{\alpha}P(\mathbf{n};t).$$

+ Initial Condition: $P(n,0)=P_0(n)$

- Deterministic evolution equation: quasi-mean values (Ordinary differential equation)

$$\frac{dn_k^{\beta}}{dt} = \sum_i \nu_{ki} n_i^{\beta} \exp\left[u_k^{\beta}(\mathbf{n}_{ki}) - u_i^{\beta}(\mathbf{n})\right] - \sum_j \nu_{jk} n_k^{\beta} \exp\left[u_j^{\beta}(\mathbf{n}_{jk}) - u_k^{\beta}(\mathbf{n})\right],$$

$$i,j,k = N,C \text{ y } \beta = 1,2.$$

+ Initial Condition: $n_k^{\beta}(0) = n_{k0}^{\beta}$

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SOCIODYNAMIC (Weidlich):

- Master Grade work example:

$$\begin{cases} n_N^1 + n_C^1 = 2M, \\ n_N^2 + n_C^2 = 2N. \end{cases}$$

$$\begin{cases} x = \dfrac{1}{2M}(n_N^1 - n_C^1), \quad -1 \le x \le 1, \\ y = \dfrac{1}{2N}(n_N^2 - n_C^2), \quad -1 \le y \le 1, \end{cases}$$

$$\begin{cases} \nu_1 = \nu_{NC}^1 \exp\left(\dfrac{\kappa^{11}}{2}\right), \\ \Delta\tilde{u}^1 = \dfrac{1}{2} xM\kappa^{11} + \dfrac{1}{2} yN\kappa^{12}, \\ \nu_2 = \nu_{NC}^2 \exp\left(\dfrac{\kappa^{22}}{2}\right), \\ \Delta\tilde{u}^2 = \dfrac{1}{2} xM\kappa^{21} + \dfrac{1}{2} yN\kappa^{22} \end{cases}$$

$$\begin{cases} \dfrac{dx}{dt} = 2\nu_1 \left\{ \operatorname{senh}(\Delta\tilde{u}^1) - x\cosh(\Delta\tilde{u}^1) \right\}, \\ \dfrac{dy}{dt} = 2\nu_2 \left\{ \operatorname{senh}(\Delta\tilde{u}^2) - y\cosh(\Delta\tilde{u}^2) \right\}, \\ x(0) = x_0, \\ y(0) = y_0. \end{cases}$$

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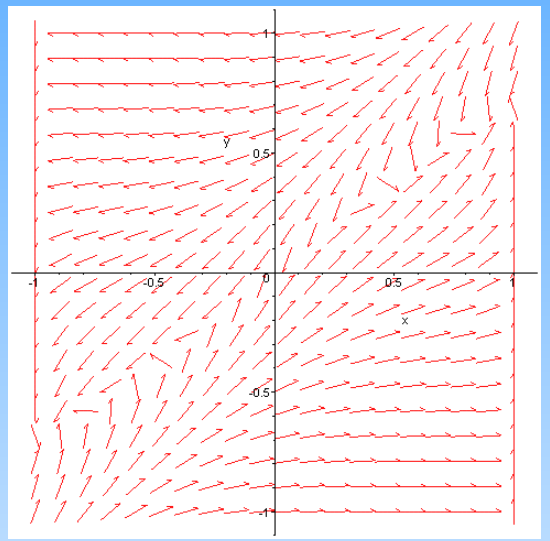
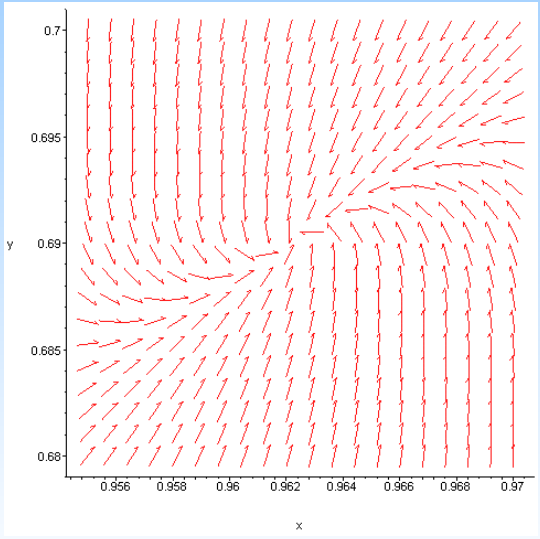
SOCIODYNAMIC (Weidlich):

- Master Grade work example:

$$\Gamma = \{(x, y) : -1 \le x \le 1, -1 \le y \le 1\}.$$

$$(x_0, y_0) \in \Gamma \Rightarrow (x(t), y(t)) \in \Gamma, t > 0.$$





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DATAWAREHOUSING TECHNIQUES & GUI:

- Dimensional Model: a way to organize and store information. Information is stored in tables called Dimensions (time, geographic,...) and Facts (e.g. offences per type, location, time...)
- Very powerful for direct calibration, validation, simulation: parameters of the Sociodynamic model will be estimated as a result of direct queries in the Dimensional Model
- **Users** can analyze the crime trends by defining groups of population selecting geographical, time and other information (subsets of the Dimensions, Initial Conditions) through a GUI
- **The System** will calibrate the model using the information in Facts and Dimensions
- **Model behaviour** will be calculated and validated. Simulation of different scenarios will be incorporated